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(54) **FOAMED RESIN COMPOSITIONS AND
METHODS OF USING FOAMED RESIN
COMPOSITIONS IN SUBTERRANEAN
APPLICATIONS**

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(57) **ABSTRACT**

Methods are provided that include a method comprising: providing a foamed resin composition comprising a resin, a foaming agent, a compressible gas, and an aqueous fluid; and introducing the foamed resin composition into at least a portion of a subterranean formation. Additional methods are provided.

FOAMED RESIN COMPOSITIONS AND METHODS OF USING FOAMED RESIN COMPOSITIONS IN SUBTERRANEAN APPLICATIONS

BACKGROUND

[0001] The present invention relates to resin compositions and methods of using such compositions in subterranean formations. More particularly, the present invention relates to foamed resin compositions and methods of using such compositions, for example, to consolidate relatively unconsolidated portions of subterranean formations, to modify the stress-activated reactivity of subterranean fracture faces and other surfaces in subterranean formations, and/or for fluid diversion.

[0002] Hydrocarbon wells are often located in subterranean zones that contain unconsolidated particulates that may migrate out of the subterranean formation with the oil, gas, water, and/or other fluids produced by the wells. The presence of unconsolidated particulates (e.g., formation fines, proppant particulates, etc.), in produced fluids is undesirable in that the particulates may abrade pumping and other producing equipment and reduce the fluid production capabilities of the producing zones. "Unconsolidated subterranean zones" as that term is used herein include those that contain loose particulates and those wherein the bonded particulates have insufficient bond strength to withstand the forces produced by the production of fluids through the zones. "Zone" as used herein simply refers to a portion of the formation and does not imply a particular geological strata or composition.

[0003] One method of controlling particulates in unconsolidated formations involves placing a filtration bed containing gravel near the well bore in order to present a physical barrier to the transport of unconsolidated formation fines with the production of hydrocarbons. Typically, such so-called "gravel packing operations" involve the pumping and placement of a quantity of a desired particulate into the unconsolidated formation in an area adjacent to a well bore. Such packs may be time consuming and expensive to install. Weakly consolidated formations also have been treated by creating fractures in the formations and depositing proppant in the fractures wherein the proppant is consolidated within the fractures into hard, permeable masses using a resin or tackifying composition to reduce the migration of sand. In some situations the processes of fracturing and gravel packing are combined into a single treatment to provide a stimulated production and an annular gravel pack to prevent formation sand production. Such treatments are often referred to as "frac pack" operations.

[0004] Another method used to control particulates in unconsolidated formations involves consolidating unconsolidated subterranean producing zones by applying a resin followed by a spacer fluid, and then a catalyst. Such techniques, however, may be problematic when, for example, an insufficient amount of spacer fluid is used between the application of the resin and the application of the external catalyst. The resin may come into contact with the external catalyst in the well bore itself rather than in the unconsolidated subterranean producing zone, which may result in rapid polymerization, potentially damaging the formation by plugging the pore channels, halting pumping when the well bore is plugged with solid material, or resulting in a down hole explosion as a result of the exothermic heat generated by the polymerization. Also, using conventional resin compositions may not be practical

due, at least in part, to the high cost and flammability of most solvents used with conventional resin compositions.

[0005] One additional problem that can negatively impact conductivity and further complicate the effects of particulate migration is the tendency of mineral surfaces in a subterranean formation to undergo chemical reactions caused, at least in part, by conditions created by mechanical stresses on those minerals (e.g., fracturing of mineral surfaces, compaction of mineral particulates, etc.). These reactions are herein referred to as "stress-activated reactions" or "stress-activated reactivity." As used herein, the term "mineral surface in a subterranean formation" and derivatives thereof refer to any surface in a subterranean formation comprised of minerals and/or the surface of a particulate. These minerals may comprise any mineral found in subterranean formations, including silicate minerals (e.g., quartz, feldspars, clay minerals), carbonaceous minerals, metal oxide minerals, and the like. The mineral surface in a subterranean formation treated in the methods of the present invention may have been formed at any time. The term "modifying the stress-activated reactivity of a mineral surface" and its derivatives as used herein refers to increasing or decreasing the tendency of a mineral surface in a subterranean formation to undergo one or more stress-activated reactions, or attaching a compound to the mineral surface that is capable of participating in one or more subsequent reactions with a second compound.

[0006] One type of reaction caused, at least in part, by conditions created by mechanical stresses on minerals is a diageneous reaction. As used herein, the terms "diageneous reaction," "diageneous reactivity," and "diagenesis," and any derivatives thereof are used herein to refer to chemical and physical processes that move a portion of a mineral sediment and/or convert the mineral sediment into some other mineral form in the presence of water. A mineral sediment that has been so moved or converted is herein referred to as a "diageneous product." Any mineral sediment may be susceptible to these diageneous reactions, including silicate minerals (e.g., quartz, feldspars, clay minerals), carbonaceous minerals, metal oxide minerals, and the like.

[0007] Two of the principle mechanisms that diageneous reactions are thought to involve are pressure solution and precipitation processes. Where two water-wetted mineral surfaces are in contact with each other at a point under strain, the localized mineral solubility near that point is thought to increase, causing the minerals to dissolve. Minerals in solution may diffuse through the water film outside of the region where the mineral surfaces are in contact (e.g., in the pore spaces of a proppant pack), where they may precipitate out of solution. The dissolution and precipitation of minerals in the course of these reactions may reduce the conductivity of the formations by, among other things, clogging the conductive channels in the formation with mineral precipitate and/or collapsing those conductive channels by dissolving solid minerals in the surfaces of those channels.

[0008] Moreover, in the course of a fracturing treatment, new mineral surfaces may be created in the "walls" surrounding the open space of the fracture. These new walls created in the course of a fracturing treatment are herein referred to as "fracture faces." Such fracture faces may exhibit different types and levels of reactivity, for example, stress-activated reactivity. In some instances, fracture faces may exhibit an increased tendency to undergo diageneous reactions. In other instances, fracture faces also may exhibit an increased tendency to react with substances in formation fluids and/or

treatment fluids that are in contact with those fracture faces, such as water, polymers (e.g., polysaccharides, biopolymers, etc.), and other substances commonly found in these fluids, whose molecules may become anchored to the fracture face. This reactivity may further decrease the conductivity of the formation through, inter alia, increased diageneous reactions and/or the obstruction of conductive fractures in the formation by any molecules that have become anchored to the fracture faces.

SUMMARY

[0009] The present invention relates to resin compositions and methods of using such compositions in subterranean formations. More particularly, the present invention relates to foamed resin compositions and methods of using such compositions, for example, to consolidate relatively unconsolidated portions of subterranean formations, to modify the stress-activated reactivity of subterranean fracture faces and other surfaces in subterranean formations, and/or for fluid diversion.

[0010] In one embodiment, the present invention provides a method comprising: providing a foamed resin composition comprising a resin, a foaming agent, a compressible gas, and an aqueous fluid; and introducing the foamed resin composition into at least a portion of a subterranean formation.

[0011] In another embodiment, the present invention provides a method comprising: providing a foamed resin composition comprising a resin, a foaming agent, a compressible gas, and an aqueous fluid; introducing the foamed resin composition into at least a portion of a subterranean formation; and allowing the foamed resin to at least partially consolidate at least a portion of the subterranean formation.

[0012] In yet another embodiment, the present invention provides a method comprising: providing a foamed resin composition comprising a resin, a foaming agent, a compressible gas, and an aqueous fluid; introducing the foamed resin composition into at least a portion of a subterranean formation; and allowing the foamed resin composition to modify the stress-activated reactivity of at least a portion of a mineral surface in the subterranean formation.

[0013] The features and advantages of the present invention will be readily apparent to those skilled in the art. While numerous changes may be made by those skilled in the art, such changes are within the spirit of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0014] The present invention relates to resin compositions and methods of using such compositions in subterranean formations. More particularly, the present invention relates to foamed resin compositions and methods of using such compositions, for example, to consolidate relatively unconsolidated portions of subterranean formations, to modify the stress-activated reactivity of subterranean fracture faces and other surfaces in subterranean formations, and/or for fluid diversion. Other uses will be evident to one skilled in the art.

[0015] The foamed resin compositions of the present invention generally comprise a resin; a foaming agent; a compressible gas; and an aqueous fluid. One of the many advantages of the present invention is that the foamed resin compositions and methods presented herein may allow for the consolidation of relatively unconsolidated portions of subterranean formations, modification of the stress-activated reactivity of

subterranean fracture faces and other surfaces in subterranean formations, and/or fluid diversion without the use of additional flammable solvents. Other benefits, objects, and advantages will be apparent to one of ordinary skill in the art with the benefit of this disclosure.

[0016] The resins utilized in the present invention are generally two-component epoxy based resins comprising a hardenable resin component and a hardening agent component. The hardenable resin component is comprised of a hardenable resin and an optional solvent. The solvent may be added to the resin to reduce its viscosity for ease of handling, mixing and transferring. It is within the ability of one skilled in the art with the benefit of this disclosure to determine if and how much solvent may be needed to achieve a viscosity suitable to the subterranean conditions. Factors that may affect this decision include geographic location of the well and the surrounding weather conditions. An alternate way to reduce the viscosity of the liquid hardenable resin is to heat it. This method avoids the use of a solvent altogether, which may be desirable in certain circumstances. The second component is the hardening agent component, which is comprised of a hardening agent. Optionally, the hardening agent may further comprise a silane coupling agent, a surfactant, and a hydrolyzable ester for, among other things, breaking gelled fracturing fluid films on the proppant particles, and an optional liquid carrier fluid for, among other things, reducing the viscosity of the hardening agent component. It is within the ability of one skilled in the art with the benefit of this disclosure to determine if and how much liquid carrier fluid is needed to achieve a viscosity suitable to the subterranean conditions. In some embodiments of the present invention, the resin may be included in the foamed resin composition in an amount in the range of from about 0.1% to about 10% by weight of the foamed resin composition.

[0017] Examples of hardenable resins that can be used in the hardenable resin component include, but are not limited to, organic resins such as bisphenol A diglycidyl ether resin, butoxymethyl butyl glycidyl ether resin, bisphenol A-epichlorohydrin resin, polyepoxide resin, novolak resin, polyester resin, phenol-aldehyde resin, urea-aldehyde resin, furan resin, urethane resin, a glycidyl ether resin, and combinations thereof. The hardenable resin used is included in the hardenable resin component in an amount in the range of from about 60% to about 100% by weight of the hardenable resin component. In some embodiments the hardenable resin used is included in the hardenable resin component in an amount of about 70% to about 90% by weight of the hardenable resin component.

[0018] Any solvent that is compatible with the hardenable resin and achieves the desired viscosity effect may be suitable for use in the hardenable resin component of the foamed resin compositions of the present invention. Some preferred solvents are those having high flash points (e.g., about 125° F.) because of, among other things, environmental and safety concerns; such solvents include butyl lactate, butylglycidyl ether, dipropylene glycol methyl ether, dipropylene glycol dimethyl ether, dimethyl formamide, diethyleneglycol methyl ether, ethyleneglycol butyl ether, diethyleneglycol butyl ether, propylene carbonate, methanol, butyl alcohol, d'limonene, fatty acid methyl esters, and combinations thereof. Other preferred solvents include aqueous dissolvable solvents such as, methanol, isopropanol, butanol, glycol ether solvents, and combinations thereof. Suitable glycol ether solvents include, but are not limited to, diethylene glycol methyl

ether, dipropylene glycol methyl ether, 2-butoxy ethanol, ethers of a C₂ to C₆ dihydric alkanol containing at least one C₁ to C₆ alkyl group, mono ethers of dihydric alkanols, methoxypropanol, butoxyethanol, hexoxyethanol, and isomers thereof. Selection of an appropriate solvent is dependent on the resin composition chosen and is within the ability of one skilled in the art with the benefit of this disclosure.

[0019] As described above, use of a solvent in the hardenable resin component is optional, but in some instances, may be desirable to reduce the viscosity of the hardenable resin component for ease of handling, mixing, and transferring. It is within the ability of one skilled in the art, with the benefit of this disclosure, to determine if and how much solvent is needed to achieve a suitable viscosity. In some embodiments the amount of the solvent used in the hardenable resin component is in the range of from about 0.1% to about 30% by weight of the hardenable resin component. Optionally, the hardenable resin component may be heated to reduce its viscosity, in place of, or in addition to, using a solvent.

[0020] Examples of the hardening agents that can be used in the hardening agent component include, but are not limited to, piperazine, derivatives of piperazine (e.g., aminoethylpiperazine), 2H-pyrrole, pyrrole, imidazole, pyrazole, pyridine, pyrazine, pyrimidine, pyridazine, indolizine, isoindole, 3H-indole, indole, 1H-indazole, purine, 4H-quinolizine, quinoline, isoquinoline, phthalazine, naphthyridine, quinoxaline, quinazoline, 4H-carbazole, carbazole, β-carboline, phenanthridine, acridine, phenathroline, phenazine, imidazolidine, phenoxazine, cinnoline, pyrrolidine, pyrrolidine, imidazoline, piperidine, indoline, isoindoline, quinuclidine, morpholine, azocine, azepine, 2H-azepine, 1,3,5-triazine, thiazole, pteridine, dihydroquinoline, hexa methylene imine, indazole, amines, aromatic amines, polyamines, aliphatic amines, cyclo-aliphatic amines, amides, polyamides, 2-ethyl-4-methyl imidazole, 1,1,3-trichlorotrifluoroacetone, and combinations thereof. The chosen hardening agent often effects the range of temperatures over which a hardenable resin is able to cure. By way of example and not of limitation, in subterranean formations having a temperature from about 60° F. to about 250° F., amines and cyclo-aliphatic amines such as piperidine, triethylamine, N,N-dimethylaminopyridine, benzylidimethylamine, tris(dimethylaminomethyl)phenol, and 2-(N₂N-dimethylaminomethyl)phenol are preferred with N,N-dimethylaminopyridine most preferred. In subterranean formations having higher temperatures, 4,4'-diaminodiphenyl sulfone may be a suitable hardening agent. Hardening agents that comprise piperazine or a derivative of piperazine have been shown capable of curing various hardenable resins from temperatures as low as about 70° F. to as high as about 350° F. In some embodiments of the present invention, the hardening agent used is included in the hardening agent component in the range of from about 40% to about 60% by weight of the hardening agent component. In some embodiments the hardening agent used is included in the hardening agent component in an amount of about 45% to about 55% by weight of the hardening agent component.

[0021] While not required, a silane coupling agent may be used, among other things, to act as a mediator to help bond the resin to formation particulates and/or proppant. Examples of suitable silane coupling agents include, but are not limited to, N-β-(aminoethyl)-γ-aminopropyl trimethoxysilane, N-2-(aminoethyl)-3-aminopropyltrimethoxysilane, 3-glycidoxypropyltrimethoxysilane, and combinations thereof. The silane coupling agent used is included in the hardening agent

component in an amount capable of sufficiently bonding the resin to the particulate. In some embodiments of the present invention, the silane coupling agent used is included in the hardening agent component in the range of from about 0.1% to about 3% by weight of the hardening agent component.

[0022] Any surfactant compatible with the hardening agent and capable of facilitating the coating of the resin onto particles in the subterranean formation may optionally be used in the hardening agent component of the foamed resin compositions of the present invention. Such surfactants include, but are not limited to, an alkyl phosphonate surfactant (e.g., a C₁₂-C₂₂ alkyl phosphonate surfactant), an ethoxylated nonyl phenol phosphate ester, one or more cationic surfactants, and one or more nonionic surfactants. Mixtures of one or more cationic and nonionic surfactants also may be suitable. Examples of such surfactant mixtures are described in U.S. Pat. No. 6,311,773 issued to Todd et al. on Nov. 6, 2001, the relevant disclosure of which is incorporated herein by reference. The surfactant or surfactants used may be included in the hardening agent component in an amount in the range of from about 1% to about 10% by weight of the hardening agent component.

[0023] While not required, examples of hydrolyzable esters that can be used in the hardening agent component include, but are not limited to, a mixture of dimethylglutarate, dimethyladipate, and dimethylsuccinate; sorbitol; catechol; dimethylthiolate; methyl salicylate; dimethyl salicylate; dimethylsuccinate; ter-butylhydroperoxide; and combinations thereof. When used, a hydrolyzable ester is included in the hardening agent component in an amount in the range of from about 0.1% to about 3% by weight of the hardening agent component. In some embodiments a hydrolyzable ester is included in the hardening agent component in an amount in the range of from about 1% to about 2.5% by weight of the hardening agent component.

[0024] Use of a diluent in the hardenable resin composition is optional and may be used to reduce the viscosity of the hardenable resin component for ease of handling, mixing and transferring. It is within the ability of one skilled in the art, with the benefit of this disclosure, to determine if and how much diluent is needed to achieve a viscosity suitable to the subterranean conditions. Any suitable diluent that is compatible with the hardenable resin and achieves the desired viscosity effects is suitable for use in the present invention. Some preferred diluents are those having high flash points (e.g., about 125° F.) because of, among other things, environmental and safety concerns; such solvents include butyl lactate, butylglycidyl ether, dipropylene glycol methyl ether, dipropylene glycol dimethyl ether, dimethyl formamide, diethylene glycol methyl ether, ethyleneglycol butyl ether, diethylene glycol butyl ether, propylene carbonate, methanol, butyl alcohol, d'limonene, fatty acid methyl esters, and combinations thereof. Other preferred diluents include aqueous dissolvable solvents such as, methanol, isopropanol, butanol, glycol ether solvents, and combinations thereof. Suitable glycol ether liquid carrier fluids include, but are not limited to, diethylene glycol methyl ether, dipropylene glycol methyl ether, 2-butoxy ethanol, ethers of a C₂ to C₆ dihydric alkanol containing at least one C₁ to C₆ alkyl group, mono ethers of dihydric alkanols, methoxypropanol, butoxyethanol, hexoxyethanol, and isomers thereof. Selection of an appropriate diluent is dependent on the resin composition chosen and is within the ability of one skilled in the art with the benefit of this disclosure.

[0025] The resin compositions of the present invention further comprise a foaming agent. Any suitable foaming agent may be used in the foamed resin compositions of the present invention. Among other things, the foaming agent may facilitate the foaming of a resin composition. Suitable foaming agents may include, but are not limited to: mixtures of an ammonium salt of an alkyl ether sulfate, a cocoamidopropyl betaine surfactant, a cocoamidopropyl dimethylamine oxide surfactant, sodium chloride, and water; mixtures of an ammonium salt of an alkyl ether sulfate surfactant, a cocoamidopropyl hydroxysultaine surfactant, a cocoamidopropyl dimethylamine oxide surfactant, sodium chloride, and water; hydrolyzed keratin; mixtures of an ethoxylated alcohol ether sulfate surfactant, an alkyl or alkene amidopropyl betaine surfactant, and an alkyl or alkene dimethylamine oxide surfactant; aqueous solutions of an alpha-olefinic sulfonate surfactant and a betaine surfactant; and combinations thereof. An example of a suitable hydrolyzed keratin is described in U.S. Pat. No. 6,547,871, the relevant disclosure of which is incorporated herein by reference. Examples of suitable mixtures of an ethoxylated alcohol ether sulfate surfactant, an alkyl or alkene amidopropyl betaine surfactant, and an alkyl or alkene dimethylamine oxide surfactant are described in U.S. Pat. No. 6,063,738, the relevant disclosure of which is incorporated herein by reference. Examples of suitable aqueous solutions of an alpha-olefinic sulfonate surfactant and a betaine surfactant is described in U.S. Pat. No. 5,879,699, the relevant disclosure of which is incorporated herein by reference. In one certain embodiment, the foaming agent comprises a mixture of an ammonium salt of an alkyl ether sulfate, a cocoamidopropyl betaine surfactant, a cocoamidopropyl dimethylamine oxide surfactant, sodium chloride, and water. In some embodiments of the present invention, the foaming agent is included in the resin composition in the range of from about 0.01% to about 6% by weight of the foamed resin composition.

[0026] The foamed resin compositions of the present invention further comprise a compressible gas. Any compressible gas that does not adversely react with or affect the other components of the resin composition may be used in accordance with the present invention. Suitable compressible gases include air, nitrogen, carbon dioxide and combinations thereof. Carbon dioxide may be contraindicated based on the resin type selected. For example, where an epoxy resin is used, the acidity of a carbon dioxide compressible gas may prevent adequate curing of the resin. Similarly, where a furan resin is chosen, the acidity of the carbon dioxide may cause premature curing and potential safety concerns. One of ordinary skill in the art, with the benefit of this disclosure, will recognize situations wherein carbon dioxide is contraindicated. In some embodiments of the present invention, the compressible gas is included in the resin composition in an amount sufficient to produce a final resin composition density from about 6 to about 12 pounds per gallon based on weight of water.

[0027] The aqueous fluid utilized in the resin compositions of the present invention may be any aqueous-based fluid, from any source, provided that it does not contain an excess of compounds that may adversely react with the other components used in accordance with this invention or with the subterranean formation. Such aqueous-based fluids may comprise fresh water, salt water (e.g., water containing one or more salts dissolved therein), brine (e.g., saturated salt water), or seawater. In some embodiments, the aqueous fluid

may be present in an amount of from about 20% to about 99.99% based on weight of water.

[0028] Optionally, the foamed resin compositions of the present invention may further comprise a gelling agent. Any gelling agent suitable for use in subterranean applications may be used in these foamed resin compositions, including, but not limited to, natural biopolymers, synthetic polymers, cross linked gelling agents, viscoelastic surfactants, and the like. Guar and xanthan are examples of suitable gelling agents. A variety of gelling agents may be used, including hydratable polymers that contain one or more functional groups such as hydroxyl, carboxyl, sulfate, sulfonate, amino, or amide groups. Suitable gelling agents typically comprise polysaccharides, biopolymers, synthetic polymers, or a combination thereof. Examples of suitable polymers include, but are not limited to, guar gum and derivatives thereof, such as hydroxypropyl guar and carboxymethylhydroxypropyl guar, cellulose derivatives, such as hydroxyethyl cellulose, locust bean gum, tara, konjak, tamarind, starch, cellulose, karaya, diutan, scleroglucan, succinoglycan, wellan, gellan, xanthan, tragacanth, and carrageenan, and derivatives and combinations of all of the above. Additionally, synthetic polymers and copolymers may be used. Examples of such synthetic polymers include, but are not limited to, polyacrylate, polymethacrylate, polyacrylamide, polyvinyl alcohol, and polyvinylpyrrolidone. Commonly used synthetic polymer acid-gelling agents are polymers and/or copolymers consisting of various ratios of acrylic, acrylamide, acrylamidomethylpropane sulfonic acid, quaternized dimethylaminoethylmethacrylate, quaternized dimethylaminoethylmethacrylate, mixtures thereof, and the like. In some embodiments, the viscosifier may be present in the foamed resin compositions of the present invention in an amount sufficient to provide a desired degree of solids suspension or viscosity.

[0029] In some embodiments, the present invention provides a method comprising: providing a foamed resin composition comprising a resin, a foaming agent, a compressible gas, and an aqueous fluid; and introducing the foamed resin composition into at least a portion of a subterranean formation.

[0030] In another embodiment, the present invention provides a method comprising: providing a foamed resin composition comprising a resin, a foaming agent, a compressible gas, and an aqueous fluid; introducing the foamed resin composition into at least a portion of a subterranean formation; and allowing the foamed resin to at least partially consolidate at least a portion of the subterranean formation.

[0031] In yet another embodiment, the present invention provides a method comprising: providing a foamed resin composition comprising a resin, a foaming agent, a compressible gas, and an aqueous fluid; introducing the foamed resin composition into at least a portion of a subterranean formation; and allowing the foamed resin composition to modify the stress-activated reactivity of at least a portion of a mineral surface in the subterranean formation.

[0032] To facilitate a better understanding of the present invention, the following examples of certain aspects of some embodiments are given. In no way should the following examples be read to limit, or define, the entire scope of the invention.

EXAMPLE 1

[0033] A sample resin composition of the present invention was prepared by first adding 0.5 grams of a gelling agent, "WG-24," which is commercially available from Halliburton Energy Services, Duncan, Okla., to 100 milliliters ("mL") of water. After hydration of the gelling agent, 1 mL of a foaming

agent, "HC-2™ Agent," which is commercially available from Halliburton Energy Services, Duncan, Okla., was added to the water and hydrated gelling agent. Next, 2.5 mL of an epoxy resin and 2.5 mL of a hardening agent were added to form a stable solution. The resulting solution was then sheared to form a foam that had a half-life of over five minutes and an initial foam quality of 71. Foam quality is the ratio of gas to the total volume of a system, expressed as a percent.

[0034] Therefore, the present invention is well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the present invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the present invention. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood as referring to the power set (the set of all subsets) of the respective range of values, and set forth every range encompassed within the broader range of values. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee.

1. A method comprising:

providing a resin composition comprising a resin and an aqueous fluid;
foaming the resin composition using a method comprising a foaming agent and a compressible gas to form a foamed resin composition; and
introducing the foamed resin composition into an unconsolidated portion of a subterranean formation.

2. The method of claim 1 wherein the resin comprises at least one resin selected from the group consisting of: bisphenol A diglycidyl ether resin, butoxymethyl butyl glycidyl ether resin, bisphenol A-epichlorohydrin resin, polyepoxide resin, novolak resin, polyester resin, phenol-aldehyde resin, urea-aldehyde resin, furan resin, urethane resin, a glycidyl ether resin, and any combination thereof.

3. The method of claim 1 wherein the resin is present in the foamed resin composition in an amount in the range of from about 0.1% to about 10% by weight of the foamed resin composition.

4. The method of claim 1 wherein the foaming agent comprises at least one foaming agent selected from the group consisting of: a mixture of an ammonium salt of an alkyl ether sulfate, a cocoamidopropyl betaine surfactant, a cocoamidopropyl dimethylamine oxide surfactant, sodium chloride, and water; a mixture of an ammonium salt of an alkyl ether sulfate surfactant, a cocoamidopropyl hydroxysultaine surfactant, a cocoamidopropyl dimethylamine oxide surfactant, sodium chloride, and water; hydrolyzed keratin; a mixture of an ethoxylated alcohol ether sulfate surfactant, an alkyl or alkene amidopropyl betaine surfactant, and an alkyl or alkene dimethylamine oxide surfactant;

dimethylamine oxide surfactant; an aqueous solution of an alpha-olefinic sulfonate surfactant and a betaine surfactant; and any combination thereof.

5. The method of claim 1 wherein the foaming agent is present in the foamed resin composition in an amount in the range of from about 0.01% to about 6% by weight of the foamed resin composition.

6. The method of claim 1 wherein the compressible gas comprises at least one compressible gas selected from the group consisting of: air, nitrogen, carbon dioxide, and any combination thereof.

7. The method of claim 1 wherein the compressible gas is present in an amount sufficient to produce a final foamed resin composition density from about 6 to about 12 pounds per gallon based on weight of water.

8. The method of claim 1 wherein the foamed resin composition further comprises a viscosifier.

9. A method comprising:
providing a resin composition comprising a resin and an aqueous fluid;
foaming the resin composition using a method comprising a foaming agent and a compressible gas to form a foamed resin composition;
introducing the foamed resin composition into at least a portion of a subterranean formation; and
allowing the foamed resin composition to at least partially consolidate at least a portion of the subterranean formation.

10. The method of claim 9 wherein the resin comprises at least one resin selected from the group consisting of: bisphenol A diglycidyl ether resin, butoxymethyl butyl glycidyl ether resin, bisphenol A-epichlorohydrin resin, polyepoxide resin, novolak resin, polyester resin, phenol-aldehyde resin, urea-aldehyde resin, furan resin, urethane resin, a glycidyl ether resin, and any combination thereof.

11. The method of claim 9 wherein the foaming agent comprises at least one foaming agent selected from the group consisting of: a mixture of an ammonium salt of an alkyl ether sulfate, a cocoamidopropyl betaine surfactant, a cocoamidopropyl dimethylamine oxide surfactant, sodium chloride, and water; a mixture of an ammonium salt of an alkyl ether sulfate surfactant, a cocoamidopropyl hydroxysultaine surfactant, a cocoamidopropyl dimethylamine oxide surfactant, sodium chloride, and water; hydrolyzed keratin; a mixture of an ethoxylated alcohol ether sulfate surfactant, an alkyl or alkene amidopropyl betaine surfactant, and an alkyl or alkene dimethylamine oxide surfactant;

an aqueous solution of an alpha-olefinic sulfonate surfactant and a betaine surfactant; and any combination thereof.

12. The method of claim 9 wherein the foaming agent is present in the foamed resin composition in an amount in the range of from about 0.01% to about 6% by weight of the foamed resin composition.

13. The method of claim 9 wherein the compressible gas comprises at least one compressible gas selected from the group consisting of: air, nitrogen, carbon dioxide, and any combination thereof.

14. The method of claim 9 wherein the compressible gas is present in an amount sufficient to produce a final resin composition density from about 6 to about 12 pounds per gallon based on weight of water.

15. A method comprising:

providing a resin composition comprising a resin and an aqueous fluid;
foaming the resin composition using a method comprising a foaming agent and a compressible gas to form a foamed resin composition;
introducing the foamed resin composition into at least a portion of a subterranean formation; and
allowing the foamed resin composition to modify the stress-activated reactivity of at least a portion of a mineral surface in the subterranean formation.

16. The method of claim **15** wherein the resin comprises at least one resin selected from the group consisting of: bisphenol A diglycidyl ether resin, butoxymethyl butyl glycidyl ether resin, bisphenol A-epichlorohydrin resin, polyepoxide resin, novolak resin, polyester resin, phenol-aldehyde resin, urea-aldehyde resin, furan resin, urethane resin, a glycidyl ether resin, and any combination thereof.

17. The method of claim **15** wherein the foaming agent comprises at least one foaming agent selected from the group consisting of: a mixture of an ammonium salt of an alkyl ether sulfate, a cocoamidopropyl betaine surfactant, a cocoamidopropyl dimethylamine oxide surfactant, sodium chloride,

and water; a mixture of an ammonium salt of an alkyl ether sulfate surfactant, a cocoamidopropyl hydroxysultaine surfactant, a cocoamidopropyl dimethylamine oxide surfactant, sodium chloride, and water;

hydrolyzed keratin; a mixture of an ethoxylated alcohol ether sulfate surfactant, an alkyl or alkene amidopropyl betaine surfactant, and an alkyl or alkene dimethylamine oxide surfactant; an aqueous solution of an alpha-olefinic sulfonate surfactant and a betaine surfactant; and any combination thereof.

18. The method of claim **15** wherein the foaming agent is present in the foamed resin composition in an amount in the range of from about 0.01% to about 6% by weight of the foamed resin composition.

19. The method of claim **15** wherein the compressible gas comprises at least one compressible gas selected from the group consisting of: air, nitrogen, carbon dioxide, and any combination thereof.

20. The method of claim **15** wherein the compressible gas is present in an amount sufficient to produce a final resin composition density from about 6 to about 12 pounds per gallon based on weight of water.

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